Understanding pre-service teacher conceptual change through slowmation animation

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Abstract
This paper is an exploration of conceptual change. It reports on a study which utilised Hewson and Lemberger's (2000) Conceptual Status Elements, and explores the unique contribution of Slowmation Animation in the conceptual learning of pre-service science teachers. 15 short animations were created by 55 participants in a single two hour tutorial class as a part of their methods training. Conceptual change was found to occur when their animation topic challenged their understandings of the processes within the scientific concept. The pre-service science teachers reported an enthusiasm for Slowmation Animation as a method for learning how to learn, as well as for highlighting what they thought they knew, but didn't really know.

Key words: conceptual change, slowmation animation, secondary science, pre-service teacher education

1. Introduction

It is a difficult call to expect a pre-service teacher to have complete conceptual knowledge across astronomy, biology, chemistry, earth science and physics when their typical university degrees are quite narrow. Many pre-service and newly qualified science teachers have gaps in their knowledge, and being able to identify and fill these gaps is half the battle (Scaife, 2008). In addition to meeting conceptual knowledge requirements in the classroom, the pre-service and newly qualified science teacher is required to be technologically literate and able to integrate computers into science activities. It is reasonable to assume that gaps in pre-service and newly qualified science teacher technological knowledge is partially responsible for Songer's (2007) finding that "computers and network technologies are often under-utilized and poorly integrated into core science education activities" (p. 471). This project aimed to explore conceptual change in pre-service science teachers as they investigated abstract scientific concepts through the creation of Slowmation Animation movies. The pre-service teachers were "learning with technology" (Jones, 2005, p.1). Jones distinguishes between learning with and learning from technology, in that learning from technology involves passive learning from a web page, a video or an audio recording. Learning with technology is "when the learners are actively engaged in a learning problem while using technology to solve that problem" (Jones, 2005, p.1). Instead of watching a video, the learner creates a video. The purpose of this paper, then, was to explore the "learning with technology" by pre-service science teachers when the technology is 'Claymation'.

'Claymation' involves the use of clay to create characters, scenery and props. These are then used to create a video in a stop motion format using a digital camera. Minute changes to the characters and props between each photograph create the appearance of movement on the screen. 'Slowmation Animation' is a simplified version of 'Claymation' that uses many of the same learning processes – "researching information, planning and writing a story, storyboarding, designing models, taking digital photographs, using visual literacies, using technology, evaluating and, most importantly, working collaboratively as a team" (Hoban, 2005, p. 27).

This paper aims to drill down into the research on slowmation to investigate more fully how the learning processes interrelate when learners are engaged in making such animations. Further, Hoban, Loughran and Neilsen (2011) state "It is clear that further research is needed to study how learners in different contexts use their own technology to design and make multimodal animations to represent science concepts" (p. 1004). Yore and Treagust (2006) also note that there is a need to investigate "the enhanced cognition that occurs during the transformation from one representation to another representation or one mode to another" (p. 208). Author 1 uses slowmation to "explore the science conceptual learning of preservice teachers as they create their own understanding whilst moving between representations" (2008a, p. 1). Kidman (2011) explained that her purpose is to probe secondary preservice teachers "learning through technology" rather than "learning from technology" when creating slowmations. According to Howland, Jonassen and Marra (2012), for learning that is supported by technologies, the learner will inquire, experiment, design, communicate with others, build models, write and visualise. This combination of skills enables deeper levels of thinking and reasoning. Our purpose, with secondary preservice teachers, has been focused on the learning and understanding of the science concept being examined within the processes of creating a slowmation rather than the finished product. As Howland and her colleagues point out: “technologies are lousy teachers, but they can be powerful tools to think with” (p. 17). We have added the emphasis to ‘think’, as we consider it essential for the creator of a slowmation to think about the science concept they are representing in order to gain any understanding of that science concept.

The question arises, how can learning with technology be used to effect conceptual change in pre-service science teachers? More specifically, the research questions addressed by the current project were:

1. How did the pre-service teachers use the ‘Slowmation Animation’ to represent their conceptual knowledge?
2. To what extent did the students demonstrate conceptual change?
3. In what ways did the ‘Slowmation Animation’ support pre-service teacher learning during the project?

2. The Design/Procedure

The overall approach to the project was based on the “constructionism” theoretical framework promoted by Papert (1980, 1991). Papert first used the term “constructionism” in his 1987 US National Science Foundation grant (award number 8751190) entitled “Constructionism: A new opportunity for elementary science education”. In the abstract for this NSF grant application he explained the term: “The word constructionism is a mnemonic for two aspects of the theory of science education underlying this project. From constructivist theories of psychology we take a view of learning as a reconstruction rather than as a transmission of knowledge. Then we extend the idea of manipulative materials to the idea that learning is most effective when part of an activity the learner experiences as constructing a meaningful product (1987, p. 2). Papert contended that students engage in deep learning when they research, design and construct an artefact or model as a representation of their knowledge. This theoretical framework has evolved from Information and Communication Technologies but has not been widely used in science education because of the lack of a process that is simple enough to enable learners to use technology to create artefacts to represent science concepts.

In the project, 55 pre-service secondary science teachers formed groups of four, to jointly develop short Slowmation Animation videos during a 2 hour tutorial class. The pre-service teachers had previously self selected into three tutorial classes as a part of their methods course. Within each tutorial class, small groups of four were formed by the participants on the basis of friendship. Each tutorial class was shown a short segment of a Wallace and Gromit video as an example of a Claymation movie, and given a short verbal and text description of the Slowmation Animation process. The tutorial class then spent about 1 hour familiarising themselves with their self selected scientific concept (approximately 45 minutes with access to the Internet and an assortment of secondary school and tertiary science text books), the plasticine materials and the Slowmation Animation processes (approximately 15 minutes). The aim of this process was to enable those with no Claymation experiences to gain some knowledge, though limited, whilst they researched their topics and planned their video. The tutorial class then proceeded to create their video. A digital recorder was placed in the centre of the work space for each group in order to record the conversations. These recordings were later transcribed for analysis. Additional data collected was in the form of planning artefacts and a completed video from each group, and a video recording of each group’s verbal explanation of their video to the class.

3. Findings/Analysis

We have identified key stages for the preservice teacher to move through in working with slowmation. The first stage is the prior knowledge or background knowledge that the learner brings to the task. The learners often begin slowmation with the knowledge they have. This initial stage of learning is the deconstructing of the Background Knowledge of the learner. The learner identifies their background knowledge, and makes it explicit with the intention of sharing it with the group. This is called the *Chunking stage*, and whether it is done as a chunking sheet, storyboard or dot points, the purpose is to bring to the group each learner’s understanding of the concept. Using Peirce’s model of Semiotic Systems, background knowledge is the object (referent), the chunking task is the representation and Making Meaning (see Figure 1) is the meaning. However, how is learning informed here? We propose that at this initial stage, the group can choose to accept one representation of the chunks (surface learning) or through discussion and planning agree by consensus on the key ‘chunks’ that need to go in their slowmation (deep learning). For the individuals in the group to make meaning of the concept, they move through Vygotsky’s Semiotic Mediation, intermental thinking (sharing prior knowledge as a group) becomes intramental thinking (internalized knowledge) through the signs the group use (their discussion, diagrams, and planning). This represents the “recursive checking of information” (Hoban, et al., 2011, p. 1002).

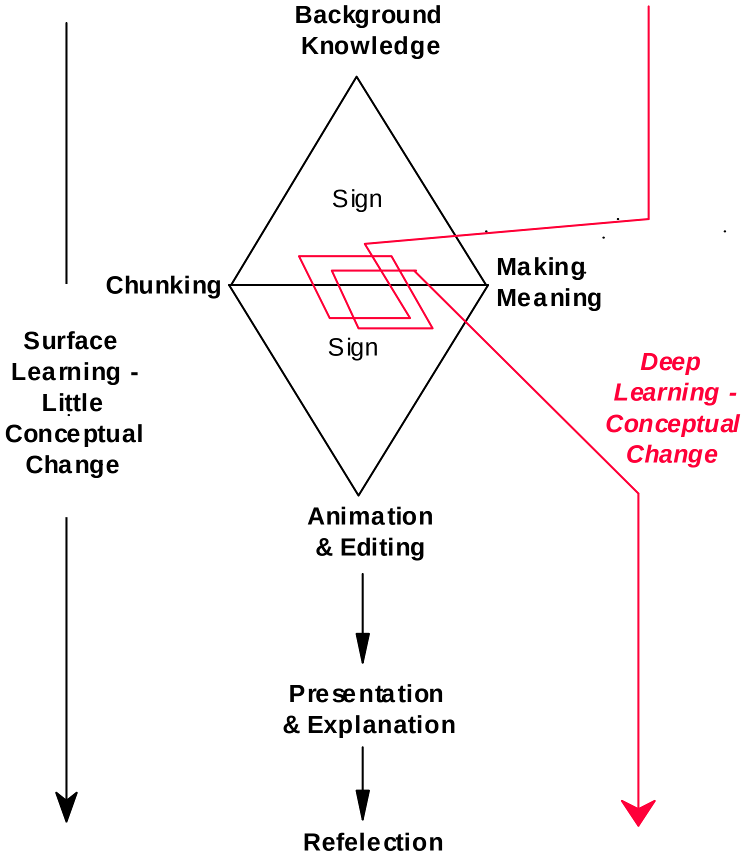

Figure 1. The Learning MMAEPER model.

Once the 'chunks' are agreed to, the group needs to reconstruct the knowledge. At the second stage, the group constructs the models, takes the photos and then builds and edits the animation. By taking the chunks as the object, and creating representations in the form of models and the animation, the learner makes meaning of the concept. The learning at this stage occurs as the learners are involved in Vygotsky's Semiotic Mediation - they discuss their ideas and understanding, grapple with production as they translate chunks into models, and reconstruct the chunks into a coherent process as they construct models and animate these. The intermental thinking is based on the chunking concepts they have developed, as the preservice teachers build models and animate them, they are individually involved in thinking and problem solving (intramental thinking). Their learning is mediated through the discussion, constructing the models and creating the animation. In this model, learning occurs when background knowledge is socially chunked allowing individual's "making meaning"; the MMAEPER (pronounced mapper) is the part of the model, that through signs, an agreed external representation is released to reveal the learning. The left hand side of the Learning MMAEPER model represents surface learning.

Surface and Deep Learning

In the third stage of the Learning MMAEPER Model, the learners present their animations and explain them. Learners present their animations and explain the scientific process to their peers. Typically the teacher/lecturer will ask questions (and often peers as well) to ascertain the accuracy of the representation. Often these slowmations are not polished pieces, rather they are an artifact of the process of the learner's knowledge construction from the prior knowledge they brought to the task, compared to that which they had at completion. This explanation stage is critical as it is an opportunity for the learner to talk their way to understanding as they stand in front of their peers and show their slowmation.

While the above explanation of the Learning MMAEPPER Model represents the learners deeply engaged in both their own learning and the slowmation task, there are those who only surface learn when creating a slowmation. A group may move down the left hand side of the Learning MMAEPER model and rarely engage with the kinds of discussions that help learners internalize or enhance their understanding of the knowledge – undergo very little conceptual change.

They may feel they are expert and the ideas need no further explanation, or they may feel out of their knowledge comfort zone and feel they know little about the topic or concept. There may be a dominant member in the group who takes control and the group has to follow them.

To tease out the difference between surface and deep learning along with conceptual change that may occur when creating a slowmation, the authors of this paper employed their "Model of Translation between Representations" (Kidman, Keast & Cooper, 2012). Figure 2 presents this model which is useful in recognizing the processes learners engage in so that creating a slowmation involves learning for the learners. The authors believe this to be a useful model to allow teachers to recognize deep learning from surface learning as it identifies the key elements of learning in slowmation and could be a useful guide to move their learners towards deep learning by asking key questions. When learners reconstruct the knowledge using their own representations and are satisfied with their explanations of the links between their chunks, it is a good indication of the process of deep learning.

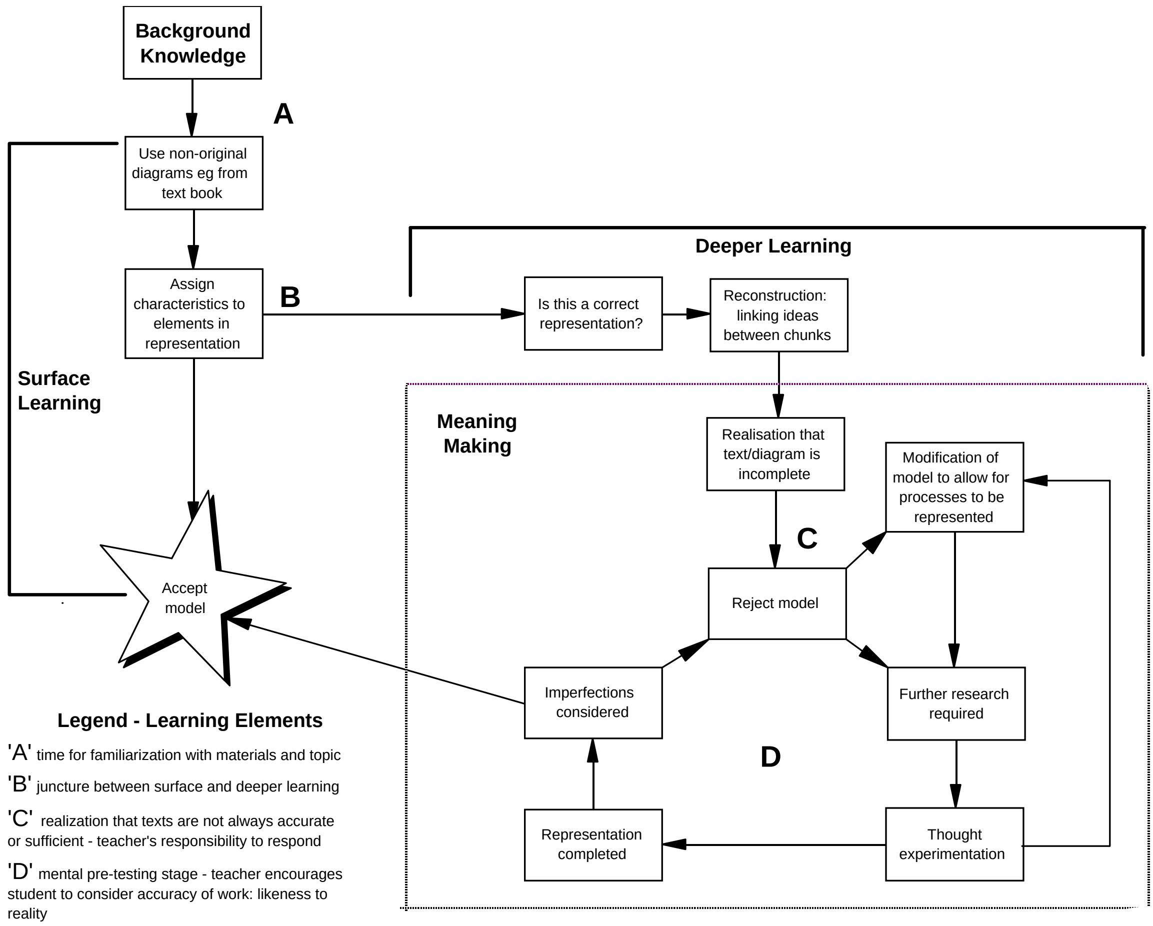

Figure 2: Model of learning and relearning through slowmation (Source: Kidman, Keast & Cooper, 2012)

In the Learning and Relearning Model, there are two pathways and four learning elements. An initial recall or copying of a diagram is often used to familiarize the learner with the concrete model making materials. Should the learner simply accept this diagrammatic representation, or perhaps just change a few aspects of representation by adding in information from a separate source, the learner can simply create their movie and be "done". Very little analysis of the visual representation is made. This is best considered as surface learning with low conceptual change. The focus or purpose is on the production of the movie, and not on the quality, accuracy or originality of the science concept presented in the movie. Tell tale signs that surface learning is occurring in the learner were found to involve them making comments like "It was there in the book [mitosis], all the stages, so we just made them. I don't know how we would have gone if we had no diagram to begin with. It is interesting we found it easy and quick to do, while the others took so long" (Kimberley). If allowed, it is easy for the learners to get caught up in making pretty presentations rather than focusing on the accuracy of the scientific explanation. The teacher needs to continually push the learners to think about the science. The learning of science needs to occur as part of the process of creating slowmation, and this needs to be the focus, not the summative assessment. Surface learning tends to occur when the slowmation replicates the representations in the text/s.

Should the learner be more inquisitive about the science processes involved, and have a desire to produce an accurate and perhaps original movie of the science concept, then the learner moves into the deeper learning section of the learning and relearning model. Deeper learning occurs in those who explore the science by engaging with the abstract science concepts and processes as they move between representations. For deeper learning, there is a need to check and double check the scientific processes being represented. This recursive checking of information may be via referring back to support material and will manifest itself in the classroom as discussion and negotiation among group members. Another indicator of deeper learning is by contemplating the concept and reconsidering the processes against background knowledge. Kidman (2011) likened this to Justi and Gilbert's (2002) thought experiments where the model is tested in a mental state – "I imagine it actually happening. Like, I twisted and turned our model in my mind to check it was doing what we needed it to do. If it was misbehaving, I would suggest changes to my group" (Simon).

Unfortunately for some learners, especially those creating a slowmation from a reduced background knowledge relating to the concept; they flounder in the actual task of creating a movie. Sometimes groups are unable to produce a final product. Understanding and making meaning may take precedence over all other activity: "It is all very good to draw the bits of the cell at various phases of division, but nothing is telling me how it moves to a next phase. I mean, is there a hormone? Or a chemical or a a a… like a brain structure sort of thing that governs it. Nothing happens in isolation. There has to be driving force, but what is it and where is it?" (David) "Until we can find that missing force, we are stuck. We don't know how to proceed, and interestingly, the biology and chemistry folk don't know either" (Mark). Physics preservice teacher 1 saw there was a link between conceptual knowledge and pedagogy: "this is a scary awakening for me. I know I don't have to know it all, but have the skills to figure it out at an appropriate level. But today I failed terribly. I could not let go of the need for an answer. If that was in the classroom, I would have a disaster lesson". For the preservice teacher, the creation of a slowmation allowed them to experience deeper learning from two complimentary lenses – that relating to the scientific conceptions, and that relating to pedagogy.

Learning Elements

In addition to highlighting surface and deeper learning, the model of learning and relearning through slowmation presents four learning elements – each is crucial if learning is to occur: 'A' indicates time needed for the familiarization with the concrete materials and topic. 'B' indicates the juncture between surface and deeper learning. By becoming aware of surface and deeper learning through slowmation, the preservice teacher can see it is possible to teach from a surface learner perspective. That is, a teacher can supposedly 'teach' something that they have 'learnt' via surface learning, and this is a concern: "That is not going to be good enough if we have to teach it. What if a student is actually thinking about how it works, like a deep learner, what do I do then?" (Suzie). Learning element 'C' relates to the realization that publicly obtained texts and or diagrams are not always accurate or sufficient, and that it is the teacher's responsibility to respond accordingly. This element blends conceptual knowledge with pedagogical knowledge as described by a Mickey, a chemistry preservice teacher: "It's funny. The text book uses all nice colours, but logic tells me it is impossible to see these colours because we needed to use a blue stain. It all looked varying shades of blue. How do I deal with that in the classroom?" Learning element 'D' is a mental pretesting stage where the accuracy of the model is considered – to consider a likeness to reality: "You know, like I need to check my answers in maths, I need to get the kids to check their ideas in science too. I want to tell them to remember all they did, and to sort of relive the experiment to see if the answer makes sense. I do the same here. I ask myself if my representation is the same but different – an improvement – from what is shown in the book. It is important for teaching that I get it right" (June). The teacher can use this mental retesting in the classroom by not having to reteach ideas, but to ask key questions and let students work through their ideas towards a better understanding.

Conceptual Knowledge

Pre-service science teachers were able to represent their conceptual knowledge through:

1. Self Generated Questions (SG),
2. Argumentation (A) and,
3. via a need for Attention to Detail (AD).

All group conversations revealed self generated questions which indicated that the pre-service science teachers were intellectually engaged with the science topic at hand. Many self generated questions were concerned with the real life physical appearance. Appearance, or visual image, seemed more important than the processes involved in terms of self generated questions as the following two excerpts indicate: (SG 2) "We are using shapes to show different bits on the chromosomes. What do you recon the real bits look like?" (SG 5) "If DNA is like white snot, why are we using different colours?" Not all groups used argumentation to represent their conceptual knowledge. In one group, what initially appeared to be a simple error in the use of the word 'symmetry', quickly became an exploration of symmetry, resulting in the self generation, through argument, of meanings for symmetry, size, and congruence: (A 1) "No not symmetry. That is a maths topic not science. It means if you cut it in half each half matches the other." (A 2) "A maths topic? No, not just a maths topic. It is everywhere, so there will be a symmetry in a chromosome. But you are using a wrong word. You don't want symmetry in the shape sizes. You mean size." (A 2) "Yea that's what I said, size." (A 3) "But you said more – the symmetry bit. Symmetry is different. It is not relevant to what we are doing. You need to say the word that means "all the same size, shape, dimensions" sort of thing. Congruence? Maybe? There is another word though." (A 4) Congruence triangles. I remember them. We have triangles and they SIMILAR. SIMILAR is the word. We need similarity in our shapes." The need for attention to detail was present in all groups. Appearance was important but so was a need to be attentive to terminology. The creation of a slowmation video is very kinaesthetic. There appears to be a hidden visual learning component. The participants needed to get the appearance right according to their common understanding of the topic. Alignment, scale size and similarity were issues openly discussed in all groups, for example: (AD 1) Is there a size ratio thing between say the length and width of a chromosome? And thickness? Occasionally a group would also focus on the scientific processes involved as shown in the following excerpt from a gene sequencing group: (AD 3) Oh no! We didn't check the direction of the spiral. It goes clockwise .... or is it anticlockwise when it spirals? We just unravelled it. It could be wrong! Terminology was an important concern as it generated discussion on the need for correct terms instead of lay terms as shown by the following: (AD 2) You mean the chemical landmarks not bits. It is important to use the correct names or we will get confused. Keep it accurate. In addition to this, there was a very productive discussion relating to the incorrect usage, and subsequent narrow definitions of a term.

Slowmation Animation has shown to be an interesting activity enabling the exploration of pre-service biology teacher's new conceptions from a variety of status elements. The status elements which provided a reference point for determining the status of the pre-service science teacher's conception intelligibility, plausibility, and fruitfulness (Tsui & Treagust, 2007). In relation to Intelligibility, a mitosis video creation revealed analogies and images were used: (AD 3) Oh no! We didn't ... What the ...? It is wrong! Look, we play it back and we don't get two identical daughter cells. They sort of match, you know like two sisters may look similar – a family resemblance, but we need identical twins to show the mother daughter cells.(AD3) "What you have is like spaghetti, but we have only a few chromosomes so if you draw them, they should be untangled or like the little crosses". Plausibility became evident through discussions of past learning experiences and epistemological ideas: "I've done mitosis a few times. In school we did it with meiosis and used a text to write down phases but I don't recall phases correctly. I now realise how little I know. Well it comes back to me a bit when I read it, but I don't know it. I cannot teach it from the cuff like I can some other stuff" [Arthur] and "Well I just thought that if we showed the bits moving from the middle to the ends on the long strands and the cell becoming two, then it would be OK –'cause that is basically what mitosis is. I didn't think about getting it accurate, but now I think about it we should not teach anything unless it is accurate or we will get the wrong ideas across. My ideas have now changed, and I think I understand this mitosis a heck of a lot more" [Michelle]. None of the pre-service teachers indicated the status elements of fruitfulness during the 2 hour tutorial class. However, one student reported back after a four week school based practicum: "I did not get assigned to a Yr 12 biol class, but when I heard they were doing mitosis and meiosis, I asked to sit in. It was so cool as I had this secret little voice inside me saying 'I know this! I know this!' ... the teacher asked me if I would like to make a comment. So I told the class about what we did last semester. The students were interested and the teacher quickly changed her lesson and let me walk the class through the storyboarding task .... We didn't have time or equipment to do it properly, but just doing storyboarding made the lesson enjoyable for the class. The teacher was going to have them summarise the text, but by doing it my way, the class was engaged and hopefully will remember the basics better than I did when I did a text summary at school" [Michelle].

Challenging Alternative Conceptions

Many students are reluctant to participate in whole class discussions in case they offer wrong answers and suggestions. As the video is a group effort, the atmosphere during the sharing session was very supportive as it was not clear where the alternative conception originated. Arthur was a pre-service teacher who felt demoralised as his group's movie was not scientifically accurate. The following discussion took place during the explanation of the video to the class: "You could make another one that is correct, so all is not lost" [David], "Yes, but this one is still a lost cause, because it needs to reflect the science concept accurately otherwise you have wasted your time, and will teach the kids incorrect stuff" [Michelle]. "Ah, but that is where you have to think 'outside the box'. You have a video with errors – do you know all the errors? ... well? Do you?" [David] "um, no" [Michelle]. "Good, see the teacher does not need to know everything. You could give this dud one to the class, maybe in groups or as a whole class activity, and have them identify the incorrect science" [David] "YES YES (shouted enthusiastically) I see it too. If we made another one that was accurate, we could ask them to identify which video represents the correct mitosis process. Sort of like a spot the difference and explain each difference in terms of reality. Brilliant idea Dave" [Arthur]. There were numerous examples where the activity allowed the development of a supportive atmosphere where the pre-service science teachers could develop their conceptual knowledge.

4. Conclusion

There is scant published research pertaining to the use of Slowmation Animation in science education - the small number of papers are procedural in nature. Very few, if any investigate “the value of the teaching approach for student learning” (Hoban & Ferry, 2006, p.2). It is interesting that as pre-service teachers experience slowmation animation for the first time, they have an initial focus on the visual appearance of the concept which later moves onto include aspects of the processes and functions of the topic when considering self generated questions. Attention to detail in terms of scientific accuracy is not an initial concern. To some pre-service science teachers, accuracy becomes an all too consuming concern. In terms of measuring conceptual status and conceptual change, slowmation animation has shown to be an interesting activity enabling the exploration of pre-service science teacher’s new conceptions from a variety of status elements. Conceptual change may be evident when a pre-service science teacher becomes dissatisfied with their conception and representation of a concept. The dissatisfaction can lead to conceptual change sufficient to build enough confidence to take over a class and present the topic without any planning. On the other hand, dissatisfaction may in fact highlight further gaps in the pre-service teacher’s knowledge preventing them from achieving a level of confidence sufficient to teach the topic. Further research is needed to assist pre-service teachers to recognise dissatisfaction and cope with conceptual change in order to reduce the impact of gaps in their knowledge. Further research is also needed in supporting pre-service “to critically evaluate and communicate their scientific ideas with others” (Songer, 2007, p.464) during the use of ICT’s.

The authors recommend further research work to be conducted with primary preservice teachers that explore their conceptual and pedagogical knowledge development as they create slowmations in small groups. Similarly, it would be interesting to explore the quality of teaching resources that could be created by secondary science preservice teachers that takes into account the accuracy, originality of the representations of the concept, as well as the pedagogical uses of such a slowmation. To date, an emphasis on a polished slowmation product that accurately depicts an abstract scientific process has not been used in the secondary context.

The MMAEPPER model presented in this paper, may prove useful for teachers and lectures of science that use slowmation to monitor the types of learning that occur in their classrooms. What Hoban and Neilsen (2010) observed in their research occurs when individual primary preservice teachers create slowmation from their own research, moving from Background Knowledge, to Chunking, and to Animation and Editing. However, for the authors’ secondary preservice teachers working in groups or observing groups, much of the learning occurs when the learners engage in Vyogotsky Semiotic Mediation, taking knowledge created socially and internalising it for themselves. The Making Meaning addition is important as it represents this internalisation of science understanding by the learner. Further, the authors found that Author 1’s model of surface and deep processing adapted for slowmation was insightful for teachers and lecturers as an explanatory model of learning when creating slowmation. As a guide, this surface and deep processing could assist teachers to monitor the learning of their students and direct them to deeper understanding of the science concepts.

This study relating to secondary preservice teacher education indicates that deeper conceptual and pedagogical learning takes place when slowmations are created by small groups of learners. This socialisation enables multiple opportunities for the discussion and questioning of understandings of phenomenon, negotiation of external representations based on the learners internal representations, resulting in making meaning of the science phenomenon. Deeper learning will not occur unless there is this recursive checking of information at multiple times during the creation of the slowmation. The authors have found that learning can be viewed through two complimentary lenses: that of conceptual status and change, and that of pedagogical knowledge. Further work is needed to explore just how deeper conceptual learning occurs via the creation of a slowmation by either preservice teachers (both primary and secondary) or by school aged learners. Likewise, further learning is needed to explore the pedagogical uses of slowmation by preservice teachers (both primary and secondary). Finally, it would be interesting to understand how conceptual knowledge and pedagogical knowledge blend for preservice teachers using slowmation as a tool in science classrooms.

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